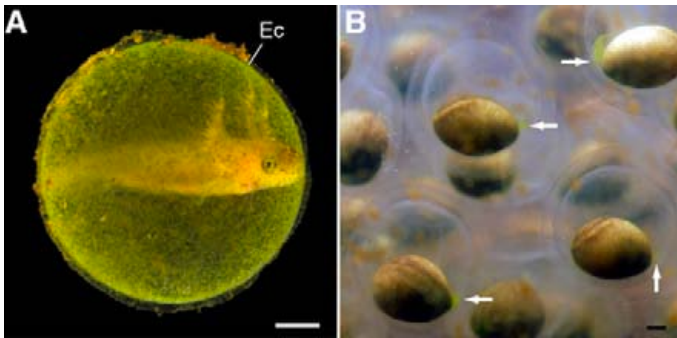


Salamander Has Algae Living Inside Its Cells



In a symbiotic union more complete than any previously found in vertebrates, the common spotted salamander lives with algae inside its cells.

Such a degree of cross-species fusion was long thought to exist only among invertebrates, whose immune systems are not primed to destroy invaders. But algae live inside the salamanders from before birth, possibly passed down from parent to offspring.

“A large number of algae cells go inside the embryo. That was something we didn’t expect,” said [Ryan Kerney, a Dalhousie University biologist](#).

That spotted salamanders and algae live in symbiosis was first noted in the 19th century, and in the 20th century researchers worked out the relationship’s mutual benefits. Salamander eggs provide a nitrogen-rich environment for algae to grow; algae oxygenate the embryos, which develop deformities without them.

But algae were believed to float outside the embryo itself, in the egg’s nutrient broth. It fell to Kerney to notice that algae’s distinctive green glow didn’t just emanate from eggs, but from inside embryos.

Those results were announced at a conference last summer, and are expanded in greater detail Apr. 5 in the [Proceedings of the National Academy of Sciences](#). The new paper adds confirmations from electron microscopy and fluorescent markers that attach to algae, flashing inside embryos and proving that Kerney’s group saw what it suspected.

Algae invade spotted salamander embryos early in their development, when individuals are just beginning to take shape inside their eggs, as the brain folds up and tissue layers-to-be first organize themselves. As an embryo develops, algae suffuses its body, but most becomes concentrated along its gut and alimentary canal.

“There are interesting things going on, and new biological processes to be investigated, in our own backyards.”

That suggests a possible role for algae in nutrient processing, though it’s an unresolved question, one of many. Another is how algae actually enter the embryo’s cells. Some unknown signal seems to trigger an algae bloom beside the embryo, but the precise moment and mechanism of invasion is a mystery.

Also unknown is whether algae drift in from water in pools where spotted salamanders lay their eggs, or are passed down from parents, though Kerney suspects both are involved

Still more questions surround whether other salamander-algae symbioses are so complete, whether different species of algae are involved, and whether such symbioses might be found in other amphibians.

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“There are so many questions that remain,” said Kerney, and all in a species that’s been studied in great detail for decades, in the lab and the wild.

Spotted salamanders are found in eastern North America and spend most of their lives underground. (Kerney stresses that, contrary to some media reports on the symbiosis, spotted salamanders are not photosynthetic.) They’re relatively easy to find in spring, when after the first warm rains they crawl outside to find vernal pools and reproduce. Kerney often sees them while walking in the woods, and even in the wheel ruts of ATV tracks.

“There are interesting things going on, and new biological processes to be investigated, in our own backyards,” he said.

possesses a [photosynthetic pathway acquired from algae](#). Unlike spotted salamanders, however, green sea slugs kill the algae: They eat it, then keep the parts. Inside spotted salamanders, algae stays alive.

Citation: “Intracellular invasion of green algae in a salamander host.” By Ryan Kerney, Eunsoo Kim, Roger P. Hangarter, Aaron A. Heiss, Cory D. Bishop, and Brian K. Hall. Proceedings of the National Academy of Sciences, Vol. 108 No. 14, April 5, 2011.



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Images: 1) At left, a late-stage salamander embryo inside its egg capsule; algae surrounds it, and is already inside it as well. At right, an early-stage salamander embryo inside its egg; algae (green, with arrows pointing) has gathered outside, waiting to enter (PNAS). 2) A spotted salamander (Ryan Kerney).

Video: Algae gathering outside salamander embryos. Watch for the green clumps to form towards the video’s end (PNAS).

*Note: Another form of animal-algae symbiosis is found in *Elysia chlorotica*, the green sea slug, which*